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The median nerve in the carpal tunnel

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A study of the variations of the course and branching pattern of the median nerve within the carpal tunnel were carried out on 60 wrists from 30 fresh cadavers autopsied in the Department of Forensic Medicine of Jagiellonian University Medical College. The results were compared with the literature. The study confirmed that the extraligamentous type of motor branch variation is most common. The transligamentous course of the nerve is of special importance: it is usually accompanied by hypertrophic muscle, and the nerve hidden within this muscle can easily be cut during transection of the retinaculum. The results proved the necessity of approaching the median nerve from the ulnar side when opening the carpal tunnel. (Folia Morphol 2011; 70, 1: 41–46)

Key words: median nerve, variation, carpal tunnel

INTRODUCTION

The carpal tunnel, located on the palmar surface of the wrist, contains the median nerve, four tendons of the flexor digitorum superficialis, four tendons of the flexor digitorum profundus, and the tendon of the flexor pollicis longus. Since the nerve passes through the narrow carpal tunnel formed by the transverse carpal ligament and the carpal bones and is crowded by the nine flexor tendons in the wrist joint area, many factors can cause increased pressure within the carpal tunnel, eventually compressing the nerve. It is therefore important for clinicians to recognize the frequency and multiplicity of the anomalous structures and variations within this region, especially the anatomical course of the median nerve and its branches.

A variety of congenital anatomical variations have been identified within the carpal tunnel by many authors: Poisel [9], Lanz [6], Tountas et al. [10], Hurwitz [4], Kozin [5], Ahn et al. [1], Lindley et al. [7], and Barbe et al. [2].

Poisel [9] examined the hands of 100 cadavers and devised a classification system for median nerve variations and the relationship of the branches to the transverse carpal ligament. He described the following three types: extraligamentous (type I), subligamentous (type II), and transligamentous (type III). Lanz [6] recorded a detailed anatomical study of the course of the median nerve in 246 hands during various surgical explorations. The variations can be classified into four types:

— type I — variations of the course of the single thenar branch;
— type II — accessory branches at the distal carpal tunnel;
— type III — high division of the median nerve;
— type IV — accessory branches proximal to the carpal tunnel.

A great deal of research has been carried out regarding median nerve variation. Tountas et al. [10] described the results of a study of 821 hands that had undergone surgery. Also represented in the study were 92 hands from cadavers. The variations were grouped

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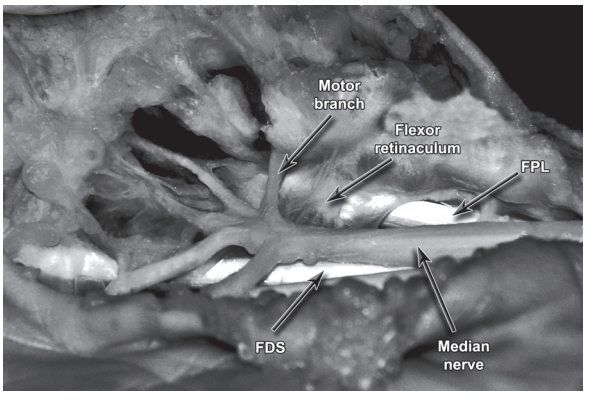

Figure 1. The thenar motor branch originating from the radial side of the median nerve, arching over the distal margin of the flexor retinaculum; FPL — flexor pollicis longus tendon; FDS — flexor digitorum superficialis tendon.

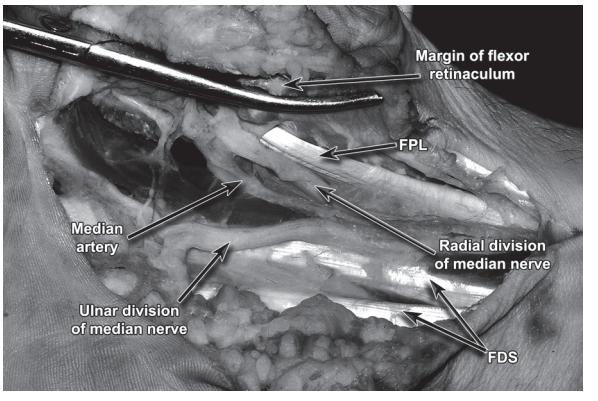

Figure 2. High division of the median nerve in association with a persistent median artery; FPL — flexor pollicis longus tendon; FDS — flexor digitorum superficialis tendon.

according Lanz's classification. Hurwitz [4] described variations of the thenar motor branch in a study of 80 surgical interventions for carpal tunnel syndrome. Kozin [5] examined 101 cadavers during anatomic dissections. Ahn et al. [1] presented anatomic variations of the median nerve from a study of 354 surgeries. Lindley et al. [7] documented variations in the carpal tunnel during the course of 526 elective carpal tunnel surgical interventions. Barbe et al. [2] examined 75 hands from various cadavers and grouped the variations according Lanz's classification. Beris et al. [3] described anatomic variations in a study of 110 surgeries.

The current study determined the variations of the median nerve in the carpal tunnel of 60 fresh cadaver hands. The results were grouped according to Poisel and Lanz classifications and compared with the results of previous studies.

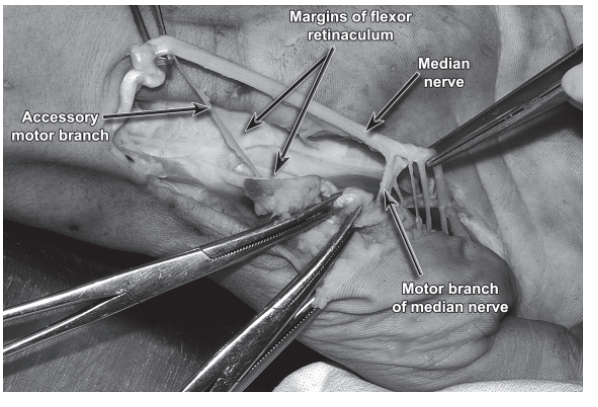

Figure 3. Accessory motor branch rising from the main stem of the median nerve, above the flexor retinaculum, entering the carpal tunnel and piercing the transverse carpal ligament.

MATERIAL AND METHODS

A total of 60 hands from 30 adult cadavers were studied during routine dissection courses and autopsies in the Department of Forensic Medicine of Jagiellonian University Medical College. There were 22 males and 8 females ranging from 23 to 92 years of age. The cadavers were examined bilaterally. The skin was incised from the distal forearm to the proximal interphalangeal joint. For each cadaver the transverse carpal ligament was opened by longitudinal incision. The carpal tunnel and palm of the hand was inspected. The variations of the median nerve and its motor branch were defined according to Poisel and Lanz classifications.

RESULTS

Examination of the cadavers showed that 43 hands had Lanz type I variant branching of the thenar branch of the median nerve (71.7%; Fig. 1) and that 17 hands had other variations (28.3%). Five of the hands had Lanz type II variations with an accessory branch at the distal carpal tunnel (8.3%). Both branches originated from the first common digital palmar nerve. High division of the median nerve (Lanz type III) was found in three hands (5%) in association with a persistent median artery (Fig. 2). An accessory branch proximal to the carpal tunnel was observed in four hands (6.7%), a variation known as Lanz type IV. After leaving the median nerve, the accessory motor branch ran within the carpal tunnel and perforated the transverse carpal ligament and gave off fibres to the muscles of the thenar eminence (Fig. 3). There were two hands in which two motor branches were observed, but the accessory motor branch originated from the median nerve in the carpal tunnel. One examined hand had

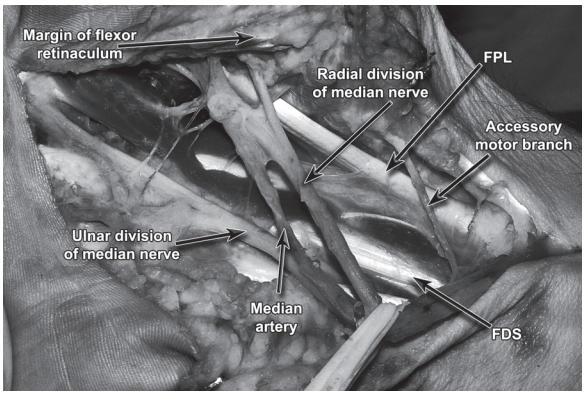

Figure 4. High division of the median nerve in association with a persistent median artery. Accessory motor branch originates above the flexor retinaculum, enters the carpal tunnel, and pierces the transverse carpal tunnel; FPL — flexor pollicis longus tendon; FDS — flexor digitorum superficialis tendon.

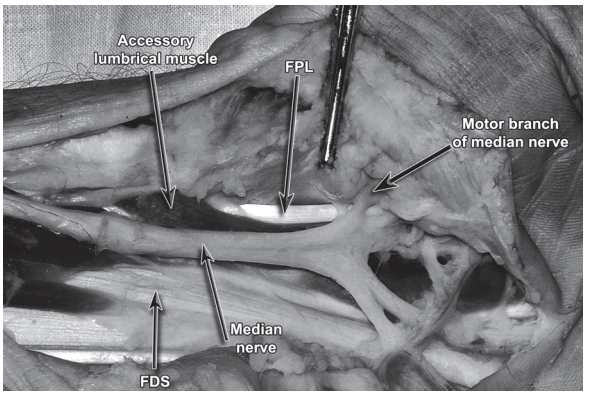

Figure 5. Accessory lumbrical muscle within the carpal tunnel; FPL — flexor pollicis longus tendon; FDS — flexor digitorum superficialis tendon.

a combination of Lanz type III and Lanz type IV. On this hand, a high division of the median nerve with persistent median artery was found, while the accessory motor branch originated from the radial part of the median nerve proximal to the carpal tunnel. The accessory branch, after entering the carpal tunnel, pierced the flexor retinaculum and reached the thenar muscles (Fig. 4). One of 60 examined hands contained an extra muscle belly within the carpal tunnel. This muscle arose from a tendon of the flexor digitorum superficialis proximal to the carpal tunnel and was inserted distally into the tendon of the flexor pollicis longus (Fig. 5).

We observed that most of the studied hands exhibited Lanz type I classification, with the most common pattern of motor branch origin from the median nerve being extraligamentous (50%; Fig. 1). The next most common variation was the subligamentous type, which was found in 20% of cases. The transligamentous course of the motor branch of the median nerve was only observed in 1.67% of cases (Fig. 6).

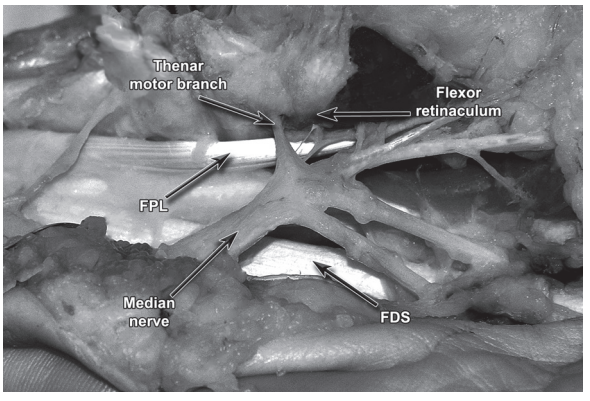

Figure 6. Transligamentous course of the thenar motor branch of the median nerve; FPL — flexor pollicis longus tendon; FDS — flexor digitorum superficialis tendon.

The thenar motor branch usually originates from the radial side of the median nerve, but variations are quite frequent. Our study confirmed that the most common location for the motor branch is the radial aspect of the median nerve (75%). Variations in the origin of the motor branch were found in 25% of cases. Branching from the ulnar side of the median nerve was found in 3.33% of cases, from the palmar (anterior) aspect in 10% of cases, and between the radial and palmar side in 11.67% of cases.

DISCUSSION

In our study, 43 out of the 60 hands were considered normal. The classical description of hand anatomy was confirmed in 71.7% of the examined hands. In 17 dissected hands (28.3%), variations of the median nerve were found.

Both clinical and cadaver studies have described the course and anatomic variations of the median nerve and its motor branch to the thenar muscle in the carpal tunnel area (Table 1).

The incidence of variations in the anatomy of the median nerve differs greatly between different reports (Table 1). The anatomical variations are frequent and there is a significant incidence of anomalous branching in this area. In three cadaveric studies (incl. the current study), the variations were found

Table 1. Frequency of the variations of the thenar branch of the median nerve within the carpal tunnel

Authors	N	Source	Variations
Lanz (1977)	246	Surgical explorations	12%
Tountas (1987)	821	Surgical explorations	8.5%
Tountas (1987)	92	Cadavers	22%
Hurwitz (1996)	80	Surgical explorations	21%
Ahn (1999)	354	Surgical explorations	18.9%
Lindley (2003)	526	Surgical explorations	1%
Barbe (2005)	75	Cadavers	36%
Beris (2008)	110	Surgical explorations	10%
Current study	60	Cadavers	28.3%

in more than 20% of subjects [2, 10]. In two clinical studies, the variations were found in about 20% of the cases [1, 4]. In other studies, variations were observed in 1% to 12% of the hands [3, 6, 7, 10]. The difference between the results obtained from clinical studies and those from cadaver studies may result from broader access to the examined region during autopsy. The differences in the results between particular clinical studies may be caused by an unclear definition of an anomaly and their various divisions. Needless to say, comparing the results between different studies is very problematic (Table 2).

Poisel [9] studied the relationship of the thenar branch to the transverse carpal ligament in 100 cadaveric hands. He found a single motor branch to the thenar muscles (Lanz type I) in 98 hands. This group was further divided into three types based on their relation to the transverse carpal ligament: extraligamentous (46% of hands), subligamentous type (31% of hands), and transligamentous type (23% of hands). In two hands, Poisel found a double motor branch coming off the median nerve in the carpal tunnel, a branch that eventually exited the tunnel by piercing the transverse carpal ligament. This variation was not described by Lanz since he paid attention mostly to the transligamentous type, pertinent in surgery of this type. Other studies did not confirm such a high frequency of transligamentous course variant of the motor branch of the median nerve.

Lanz [6] recorded an anatomical study of the course of the median nerve in 246 hands examined during surgical exploration of the carpal tunnel. The study included 217 hands (88%) with a single thenar motor branch (Lanz type I); however, no information was provided about the relationship of this branch to the transverse carpal ligament. The incidence of the extraligamentous, subligamentous, and transligamentous course of the thenar branch was adopted, in this article, after Poisel. Lanz described 29 (12%) hands with anatomical variations from this study. Accessory branches of the median nerve at the distal carpal tunnel (Lanz type II) were found in 8 (7.4%) cases. In 7 (2.9%) hands a high division of the median nerve was observed (Lanz type III). In 4 (1.7%)

Table 2. Variation of the origin of motor branch of the median nerve following Lanz's classification

Authors	N	Source	Lanz type I			Lanz type II	Lanz type III	Lanz type IV
			Extralig.	Sublig.	Translig.			
Poisel (1974)	100	Cadavers	46	31	23	–	–	–
Lanz (1977)	246	Surgical exploration	Not analysed — total 88			7.4	2.9	1.7
Tountas (1987)	821	Surgical exploration	96.7	2	1.3	0.37	0.97	0.97
Tountas (1987)	92	Cadavers	81.5	9.7	8.7	2.17	1.1	0
Hurwitz (1996)	80	Surgical exploration	55	29	16	Not analysed		
Kozin (1998)	202	Cadavers	93	0	7	Not analysed		
Ahn (1999)	354	Surgical exploration	96.1	2.8	1.1	?	0.3	?
Lindley (2003)	526	Surgical exploration	99.2	0.2	0.2	0	0.4	0
Barbe (2005)	75	Cadavers	64	33	33	0	3	0
Beris (2008)	110	Surgical exploration	?	27.3	?	0	1.8	
Current study	60	Cadavers	50	20	1.7	8.3	5	6.7

cases accessory branches proximal to the carpal tunnel were seen (Lanz type IV).

Tountas et al. [10] presented the results of a study of 821 hands that had undergone surgery. This study also included 92 cadaver hands. The variations were grouped according to Poisel's and Lanz's classification group: 96.7% were extraligamentous, 2% subligamentous, and 1.3% transligamentous. In the cadaver series 81.5% were extraligamentous, 9.7% subligamentous, and 8.7% transligamentous. Tountas et al. [10] found variations in 70 (8.5%) hands from the surgery group and variations in 21 (22%) cadaver hands. In the surgical group, Lanz type II was found in 3 hands, Lanz type III in 8 hands, and Lanz type IV in 8 hands. In the cadavers, Lanz type II was observed in two hands, and only one bifid nerve with median artery involvement was found. Lanz type IV variations were not observed.

Hurwitz [4], in a clinical study of 80 hands, described 55% as being extraligamentous, 29% as being subligamentous, and 16% as being transligamentous. In the last group, 9% of the motor branches ran within a hypertrophic periligamentous muscle. In this study, an anomalous origin of the motor branch was found in 21% of hands, and multiple motor branches occurred in 12.5% of cases. No analyses on variations according to Lanz's classification were performed.

A total of 101 cadavers were dissected by Kozin [5] to define the origin of the motor branch and to define its course with respect to the distal edge of the transverse carpal ligament. The variations were initially classified according to Poisel. Extraligamentous branches were found in 93% of the hands, and the remaining 7% were classified as transligamentous. No subligamentous type was seen in the Kozin study. Three specific types of motor branch were determined. Type I nerves were transligamentous and were found in 7% of cases. A significant number of the motor branches (74%) passed just distal to the ligament, in fascia encircling at least a portion of the nerve, through a separate tunnel (type II). Type III nerves passed distally to the transverse carpal ligament without a discrete tunnel (18%).

Ahn et al. [1] performed 354 surgical interventions in patients with carpal tunnel syndrome. This study found that the most common pathway of the motor branch of the median nerve was extraligamentous (96.1%). The next most common variation was the subligamentous type (2.8%), with the transligamentous type found in only 1.1% of cases. A single branch of the median nerve was found in 89.5% of patients, 10.2% had multiple branches, and 0.3% exhibited high division of the median nerve.

Lindley et al. [7] found variations in 30 (5.7%) out of 526 hands during carpal tunnel releases involving the median nerve and its branches, the ulnar nerve, the muscles and tendons, and the persistence of the median artery. Variations of the median nerve were observed in 5 hands (1%). The motor branch was subligamentous in only 1 hand, and transligamentous in only 1 hand as well. The high bifurcation of the median nerve was found in 2 hands, and the ulnar gave off the motor branch within the carpal tunnel in 1 hand.

Barbe et al. [2], after examining the hands of 75 cadavers, found variations in 27 hands (36%). In this study, the subligamentous and transligamentous types of the thenar branch were classified together. These variants were found in 33% of hands. The remaining 3% of hands demonstrated a high division of the median nerve (Lanz type III). No incidence of accessory branches distal or proximal to the carpal tunnel was observed (Lanz type II or type IV, respectively).

Beris et al. [3] found, intraoperatively, variations of the median nerve at the wrist in 11 (10%) of 110 patients; 27.3% of patients demonstrated a subligamentous motor branch of the median nerve. The accessory motor branch of the median nerve was not found. The incidence of proximal division was 1.8%.

The results from these studies confirm that the extraligamentous type of motor branch variation is most common. Generally, clinical observations correlate with those in the dissection laboratory. Surgery does not allow uninhibited dissection, and this may explain the somewhat higher incidence of variations in our cadaver groups. Knowledge of the variations in branching of the median nerve within and near the carpal tunnel is important when surgical decompression of the carpal tunnel is performed. The transligamentous course of the nerve is especially important. The transligamentous course is usually accompanied by hypertrophic muscle, and the nerve hidden within this muscle can be cut easily during transection of the retinaculum [8]. The studies confirm the necessity to approach the median nerve from the ulnar side when opening the carpal tunnel.

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This study was approved by local ethical committee of Jagiellonian University (No KBET/209/B/2002).

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